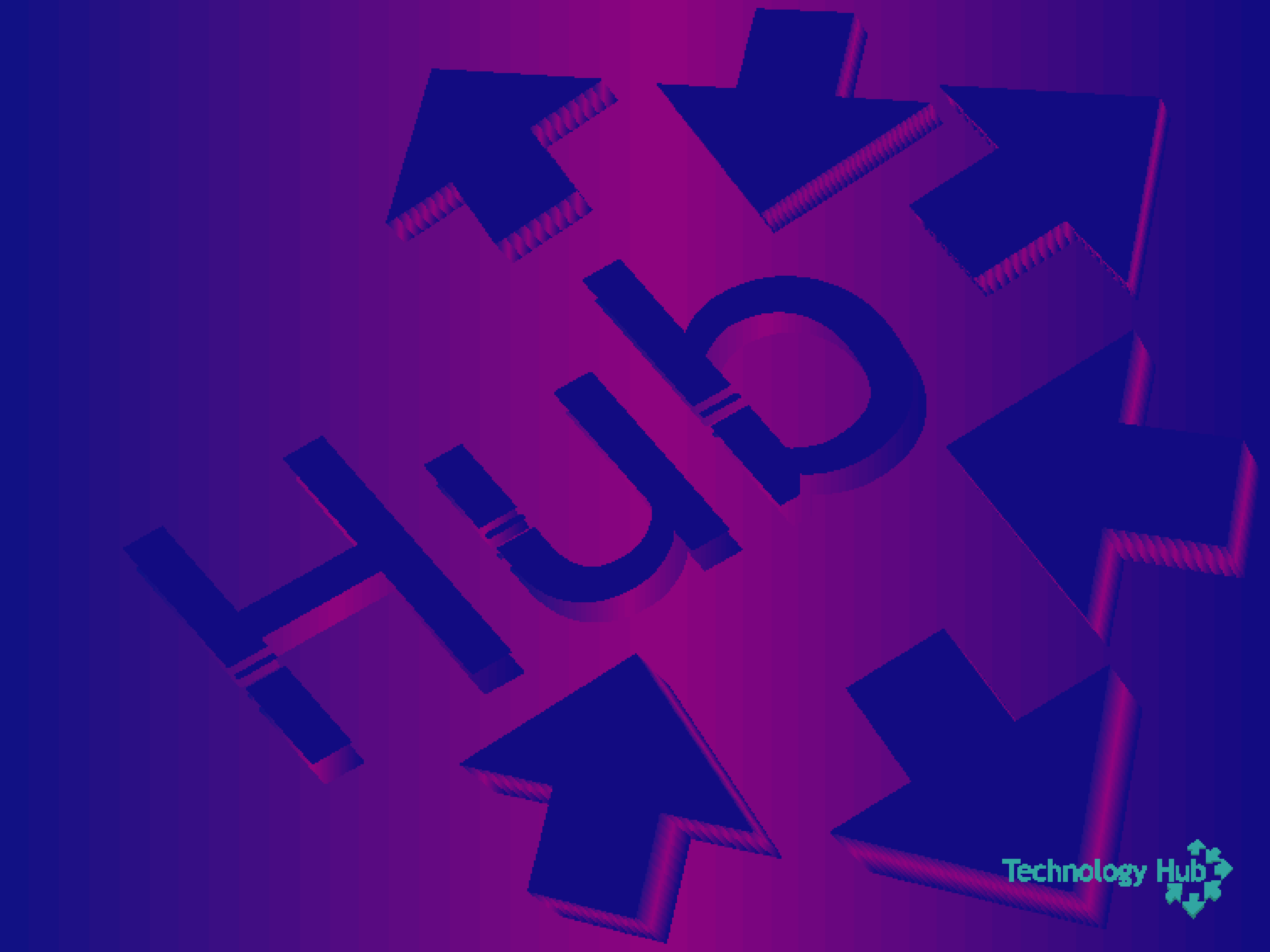
Hub
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Materials Opportunities on Layered Manufacturing Technology 2 – (MOLMT-2)

Micro-fabrication Employing UV Microstereolithography

Professor Chris Chatwin, Dr R.C.D.Young,
Dr D. Budgett, Phil Birch – University of Sussex, UK

Organised by Professor Brian Derby – Manchester Materials Science Centre, UMIST; June 3rd – 6th - 2001, Weston Conference Centre, UMIST, Manchester, UK

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Fabrication of high aspect ratio 3D micro-components

- Develop a new microstereolithography technique that operates in the UV and Visible part of the spectrum

- Manufacture micro-components which are complex in shape and have micron resolution

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Existing Technologies for MicroFabrication

- Lithography

  Components constructed by superimposing a limited number of thin film layers or by using deep UV lithography.

  Permits only limited complexity in the third dimension.

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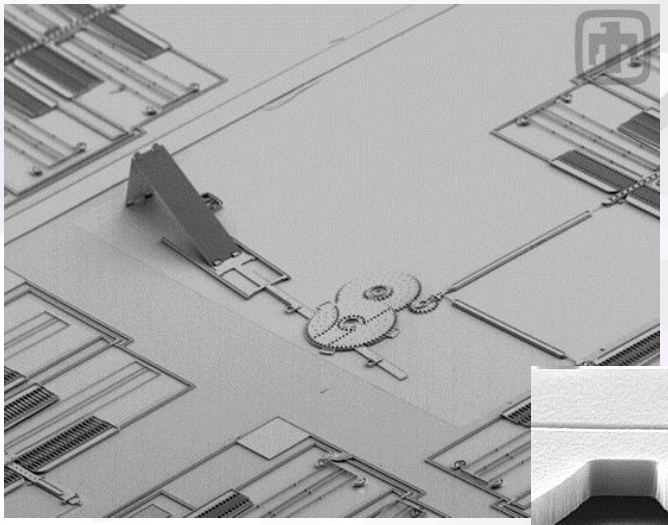
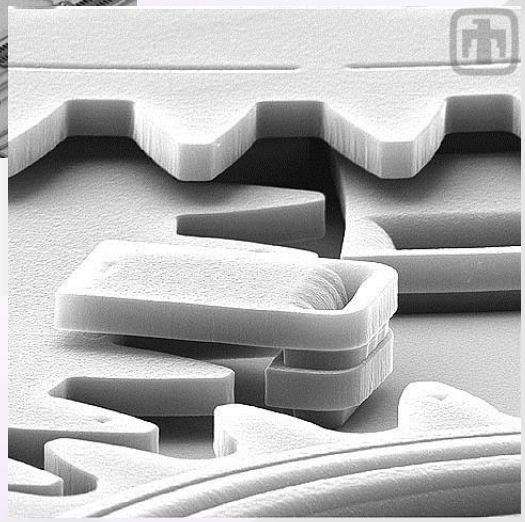
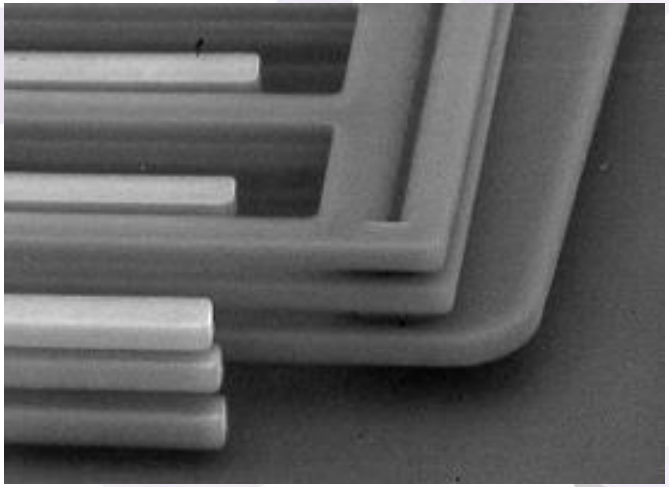
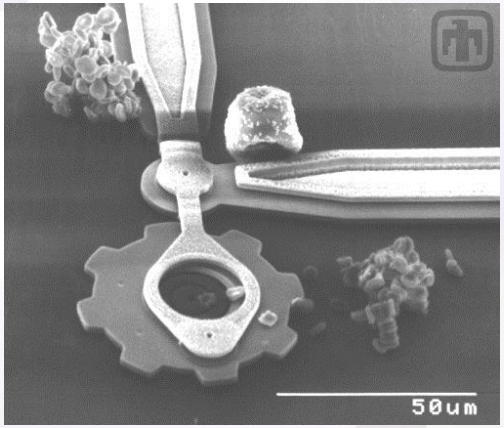
Meshing gears on a moveable platform.







A laminated comb actuator results in nearly five times the electrostatic force of a single level actuator.



Grain of pollen and red blood cells

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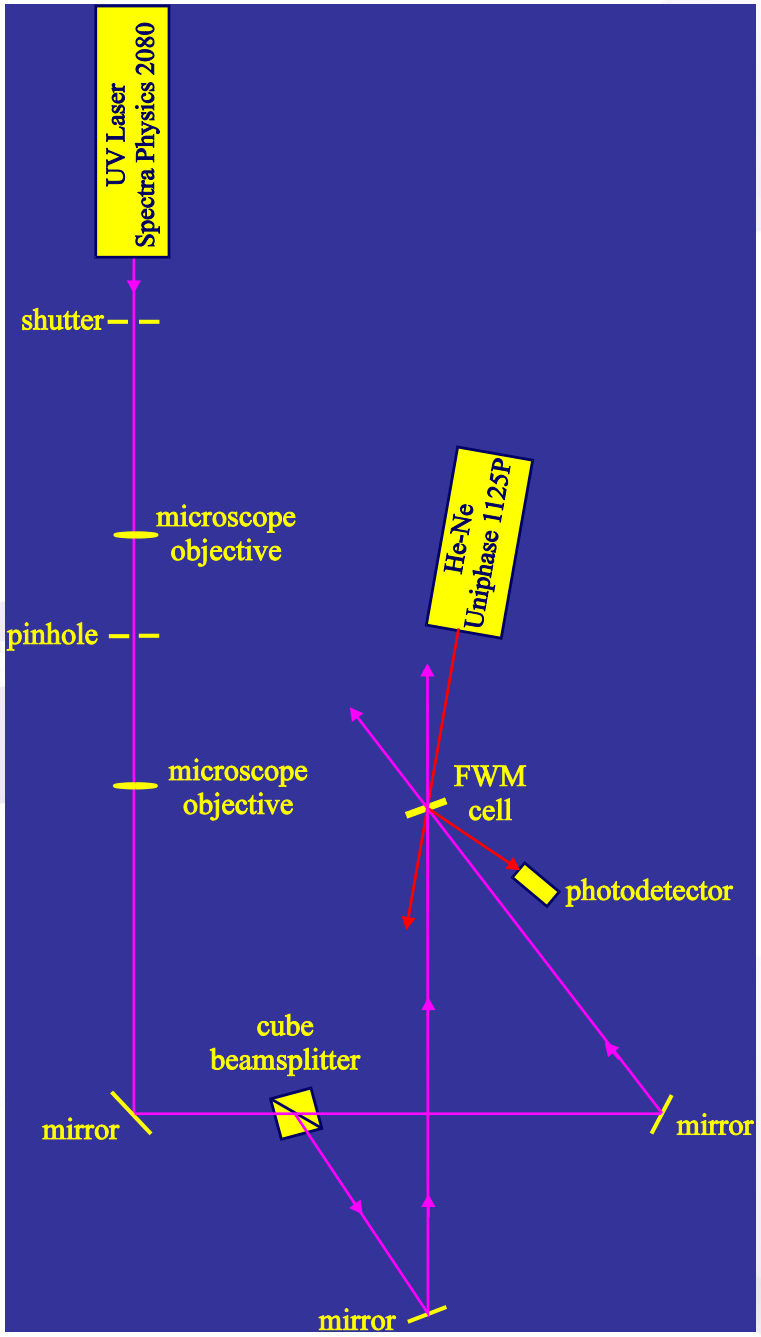
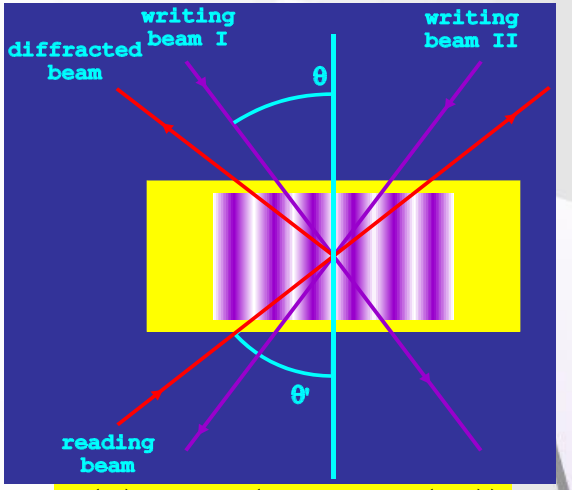
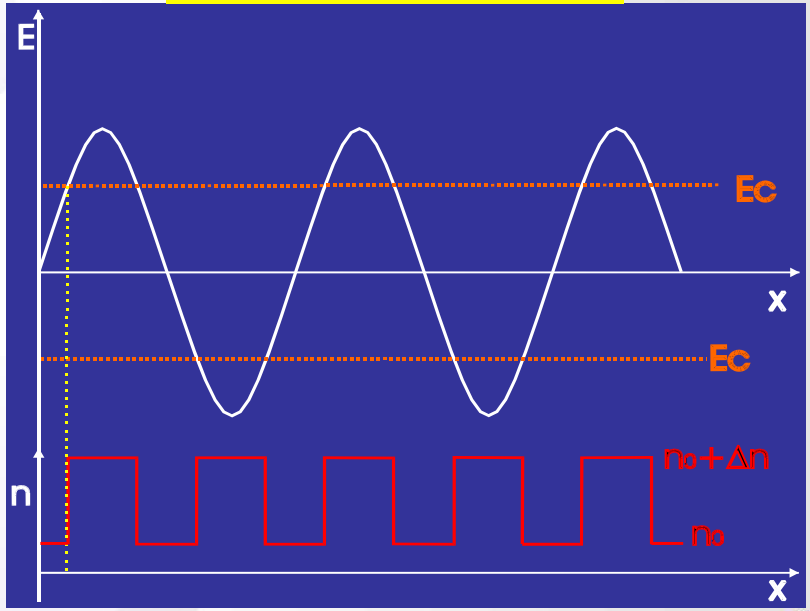




$$I(x) = I_0 \cdot (1 + m\cos(kx))$$



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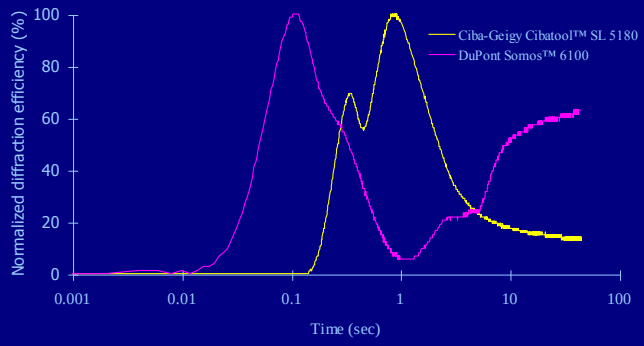
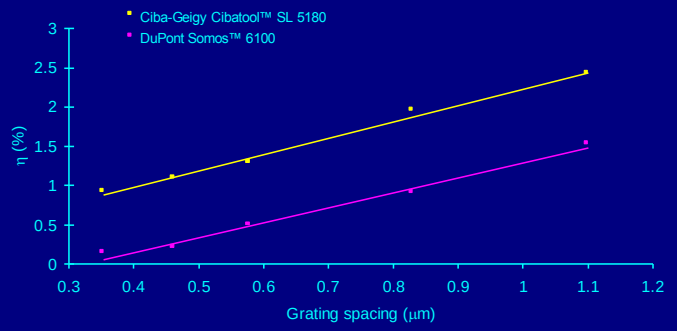
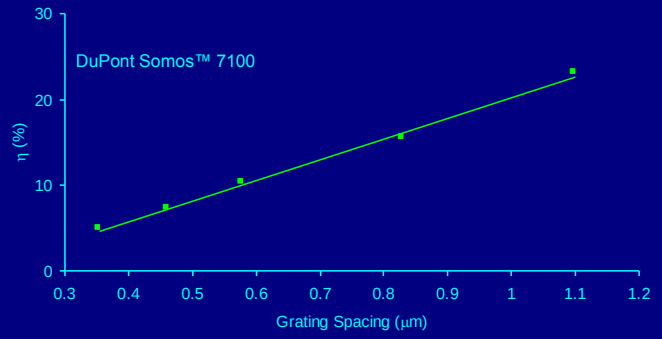
Cibatool™ SL 5180 and Somos™ 6100

Experimental Conditions:
Sample Thickness =100 μm
Temperature 19 ºC
Relative Humidity 50-60 %
Cibatool™ SL 5180:non-viscous, good quality samples
Somos™ 6100: viscous, suffers from 'bubble trapping' that causes scattering



Diffraction efficiency





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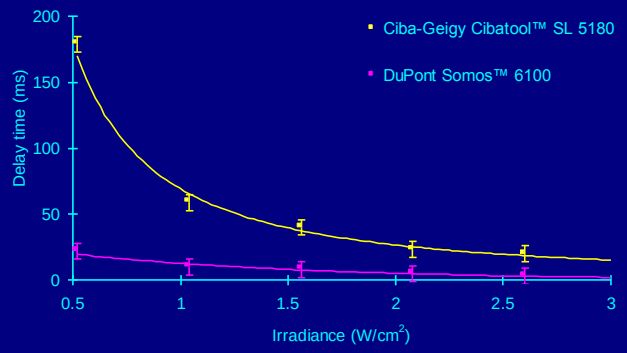
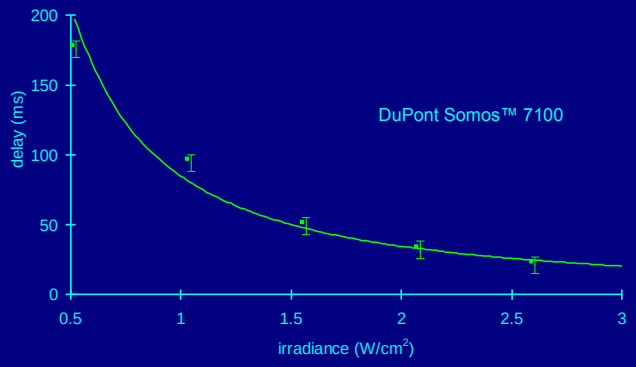
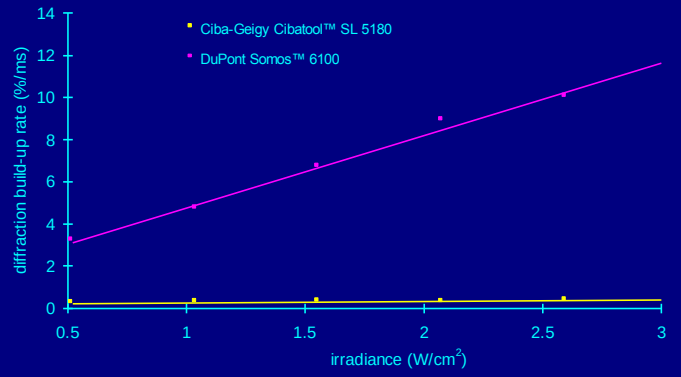
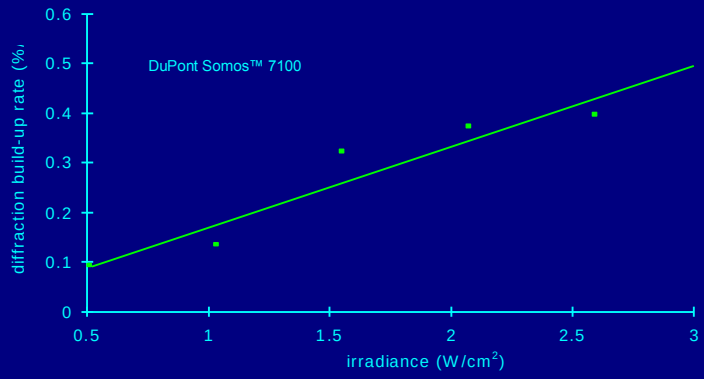
Delay





Rate





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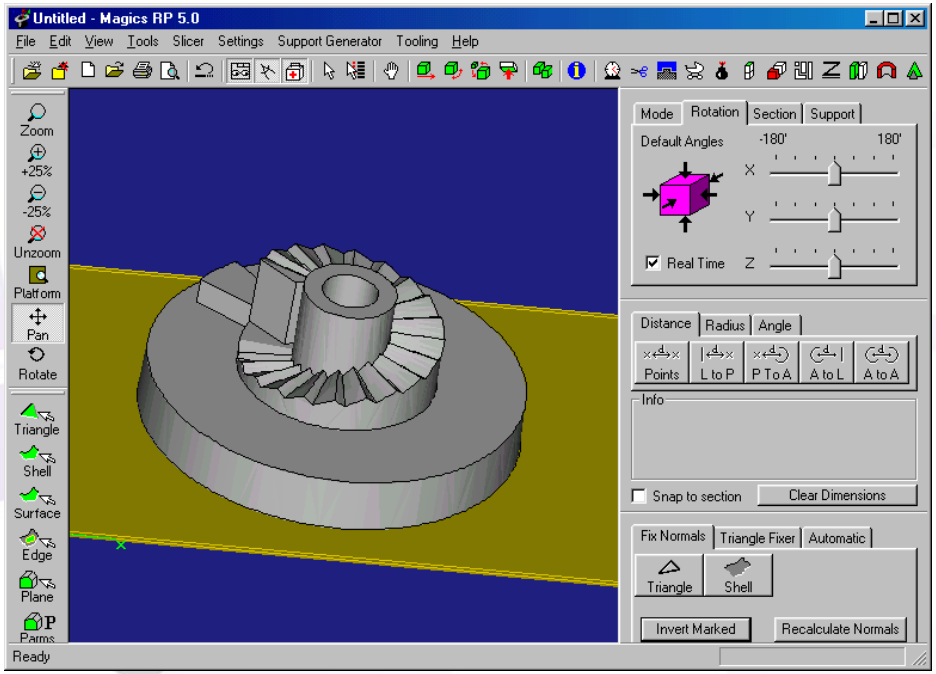
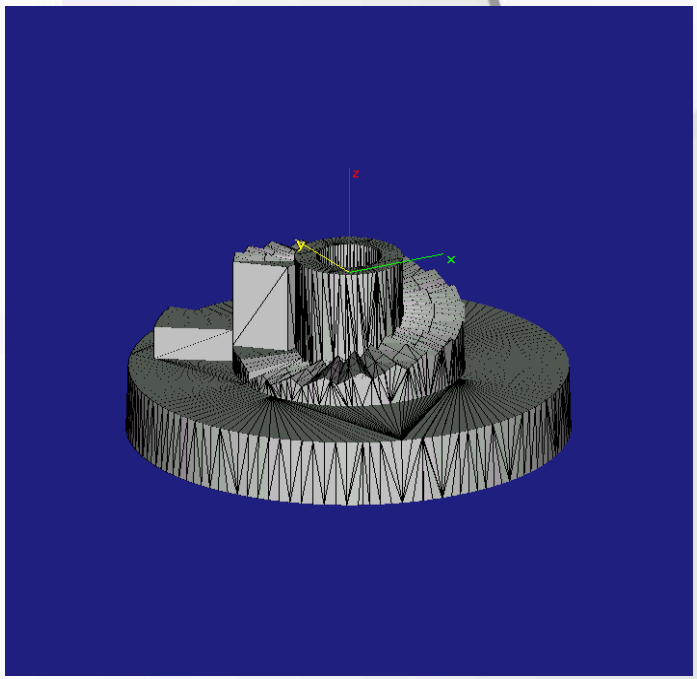
STL Interface





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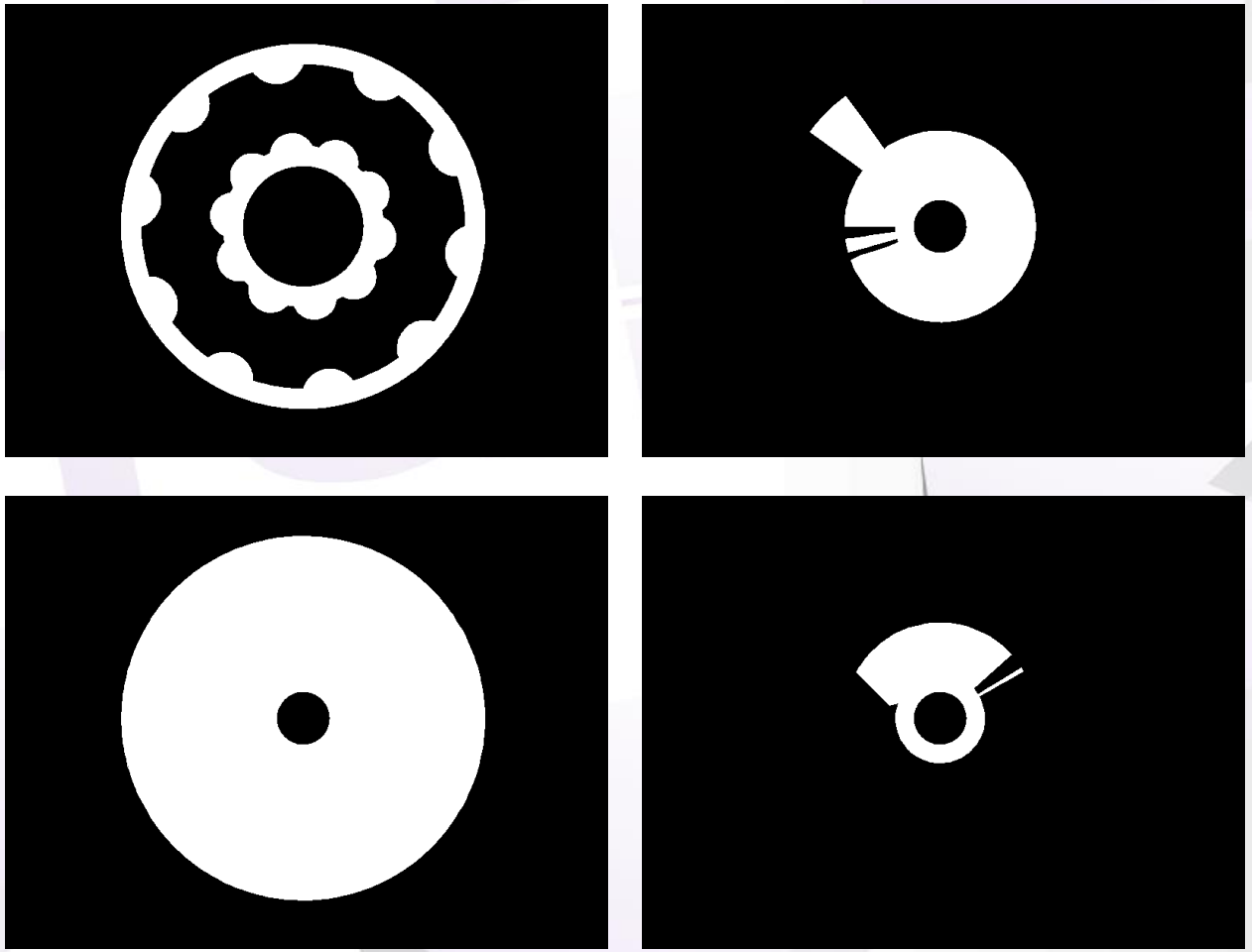
Slices from STL Model



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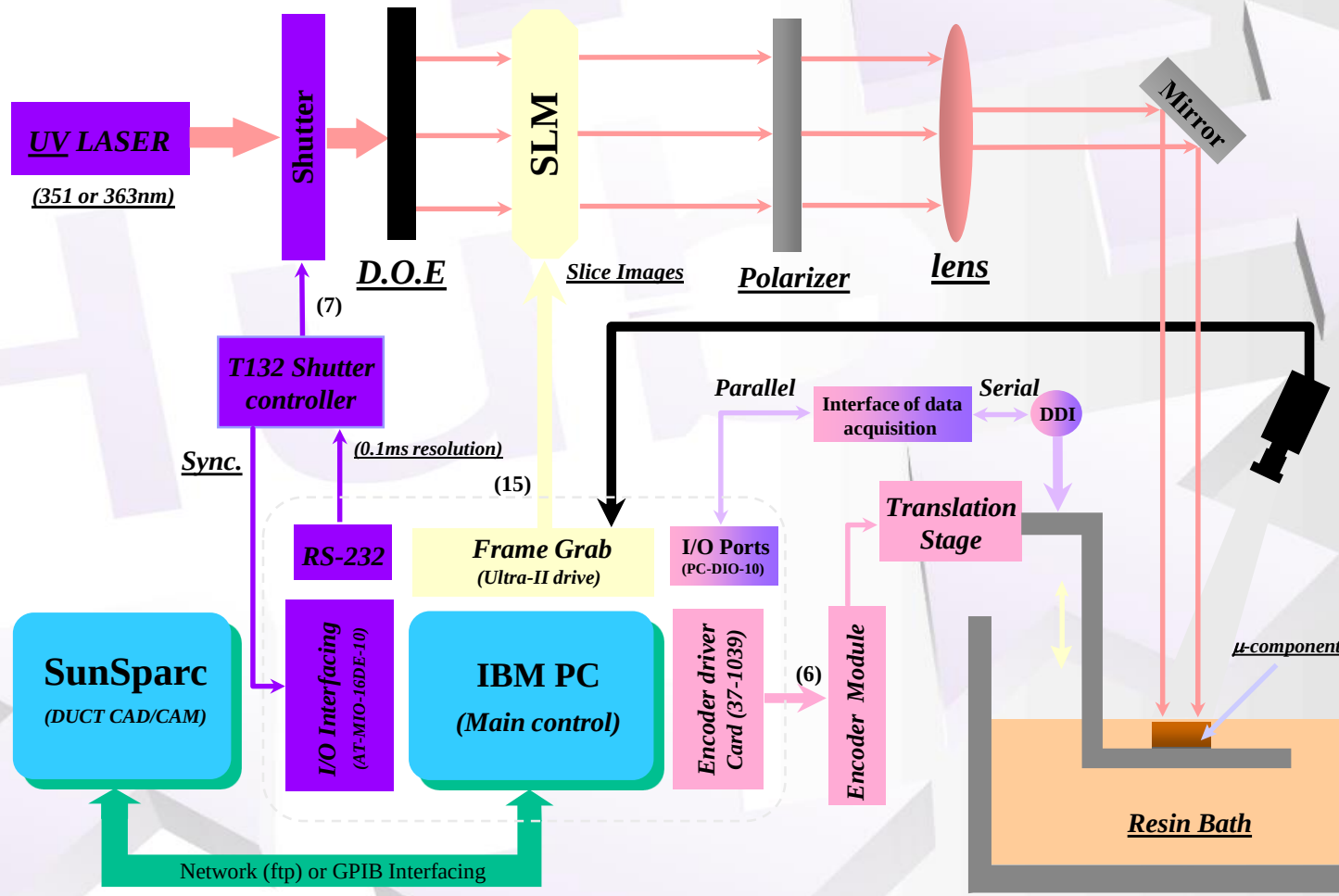
Experimental Set-up

Microstereolithography System Diagram



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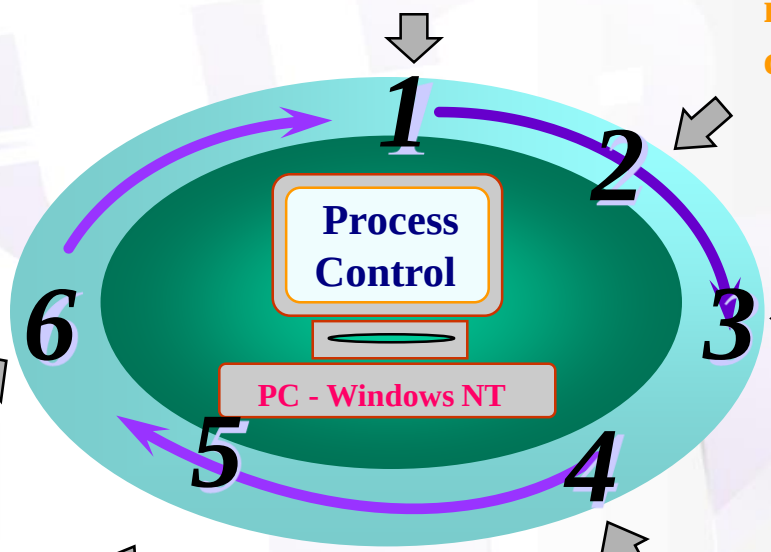
Basic Control Process



Move translation stage for re-coating

measurement and control of position

send an image slice to SLM

shutter “ON” for laser beam exposure

Shutter “OFF”

Vision system to observe the condition of the cured μ - component

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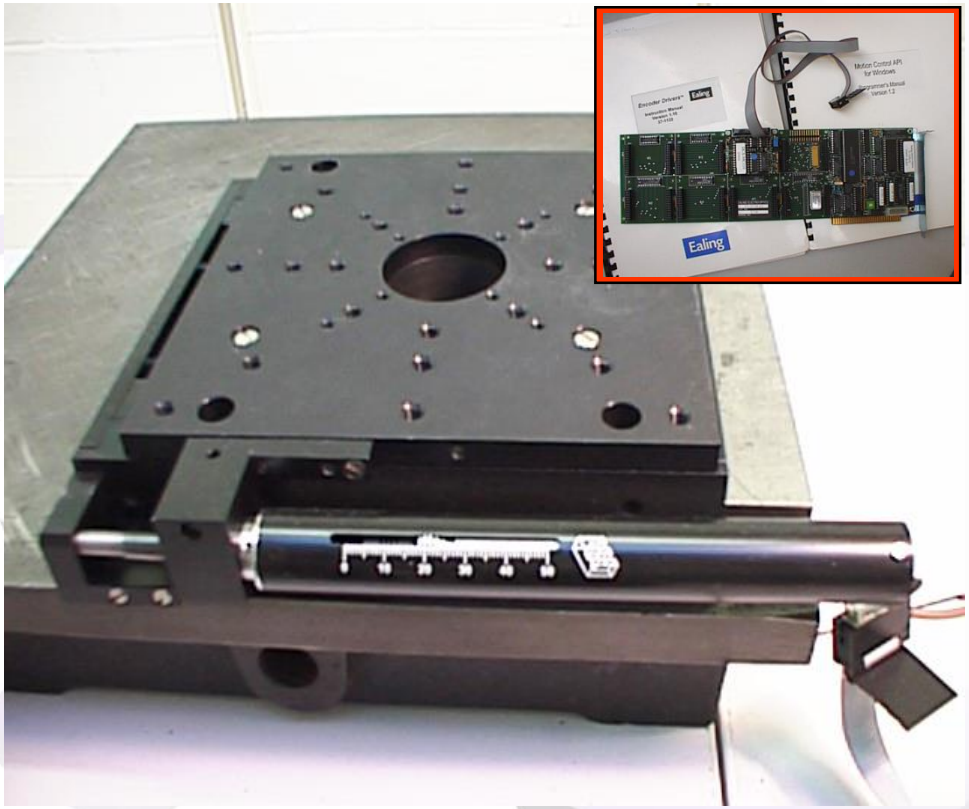
Translation Stage



Features

- 20nm resolution
- 0.1μm accuracy
- 50mm travel range
- DC servo motor
- PID feedback contol with encoder actuator
- Gearhead ratio of 485:1

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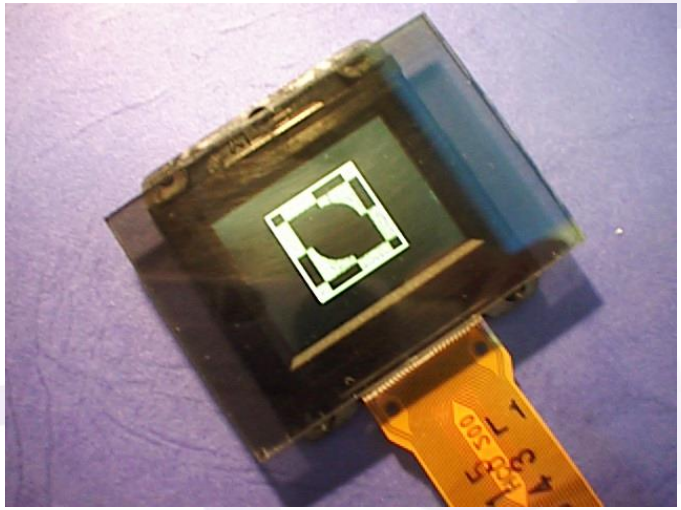
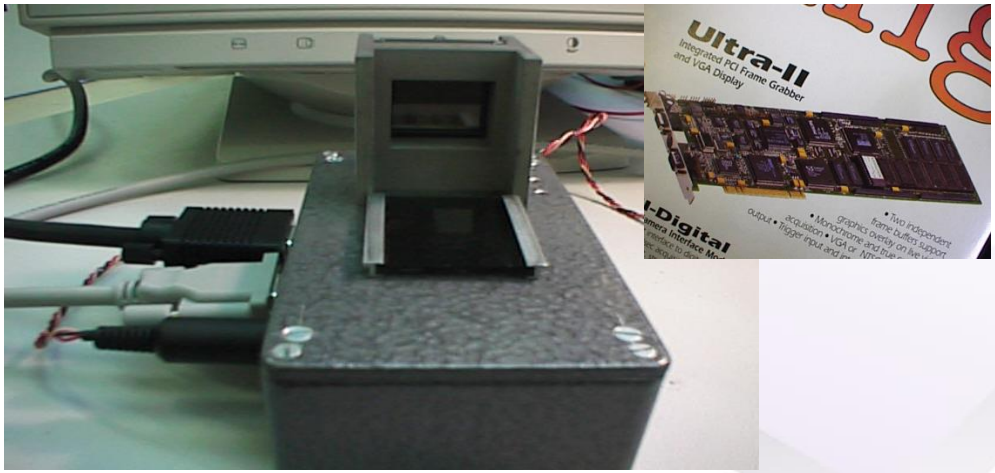
Spatial Light Modulator (SLM)



SVGA SLM 800x600 pixels



- Features
- VGA and SVGA
- Ultra-II PCI Frame Grab with video and VGA frame buffers (2Mb each)
- CCIR/PAL camera
- Overlay display

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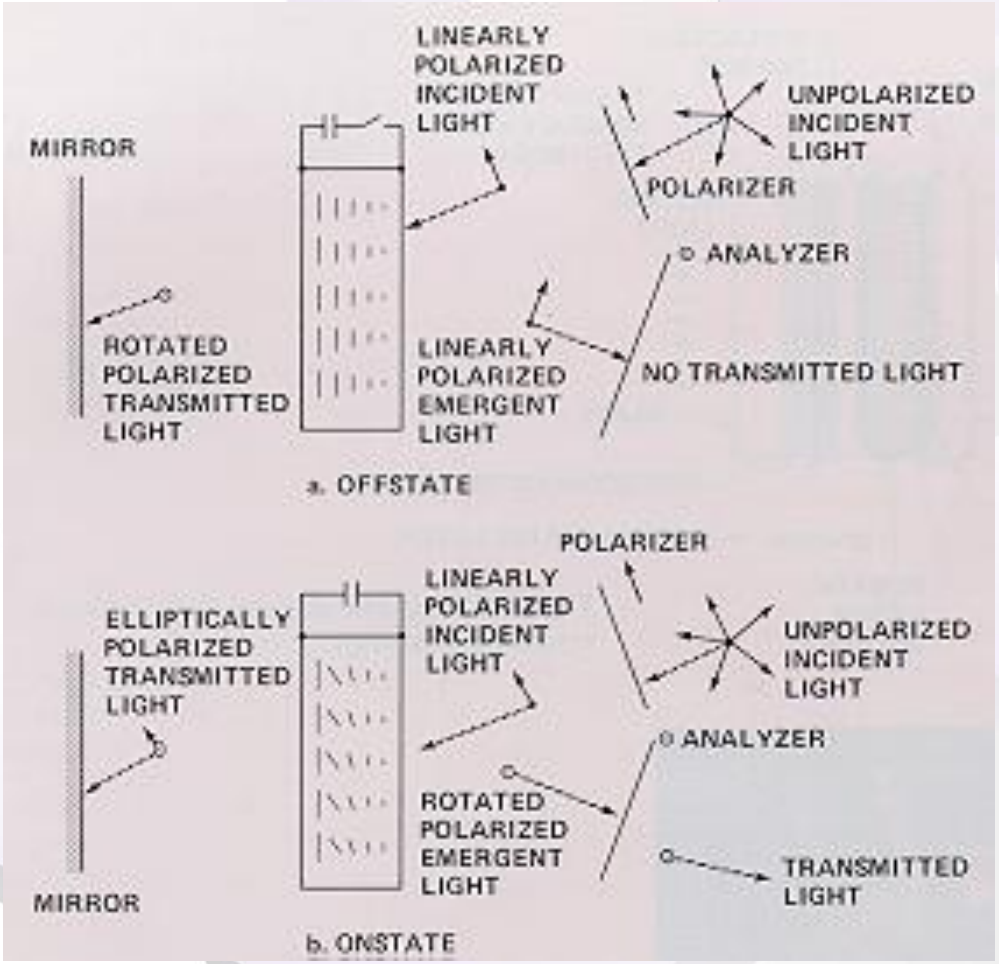
Twisted Nematic Liquid Crystal



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Reduction Lens and Photo-polymer Bath

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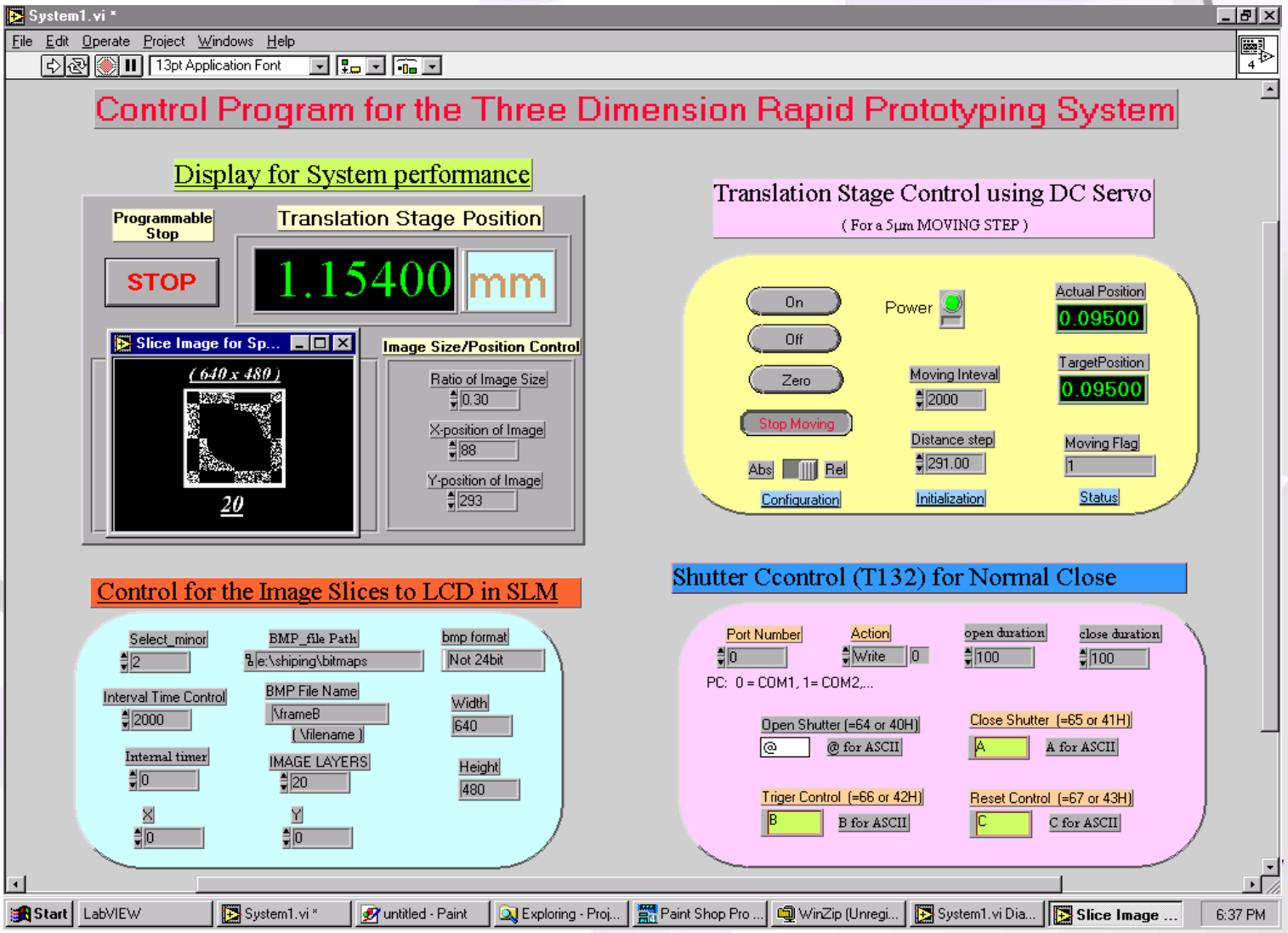
Main Programme Control Panel



Micro-SLA System

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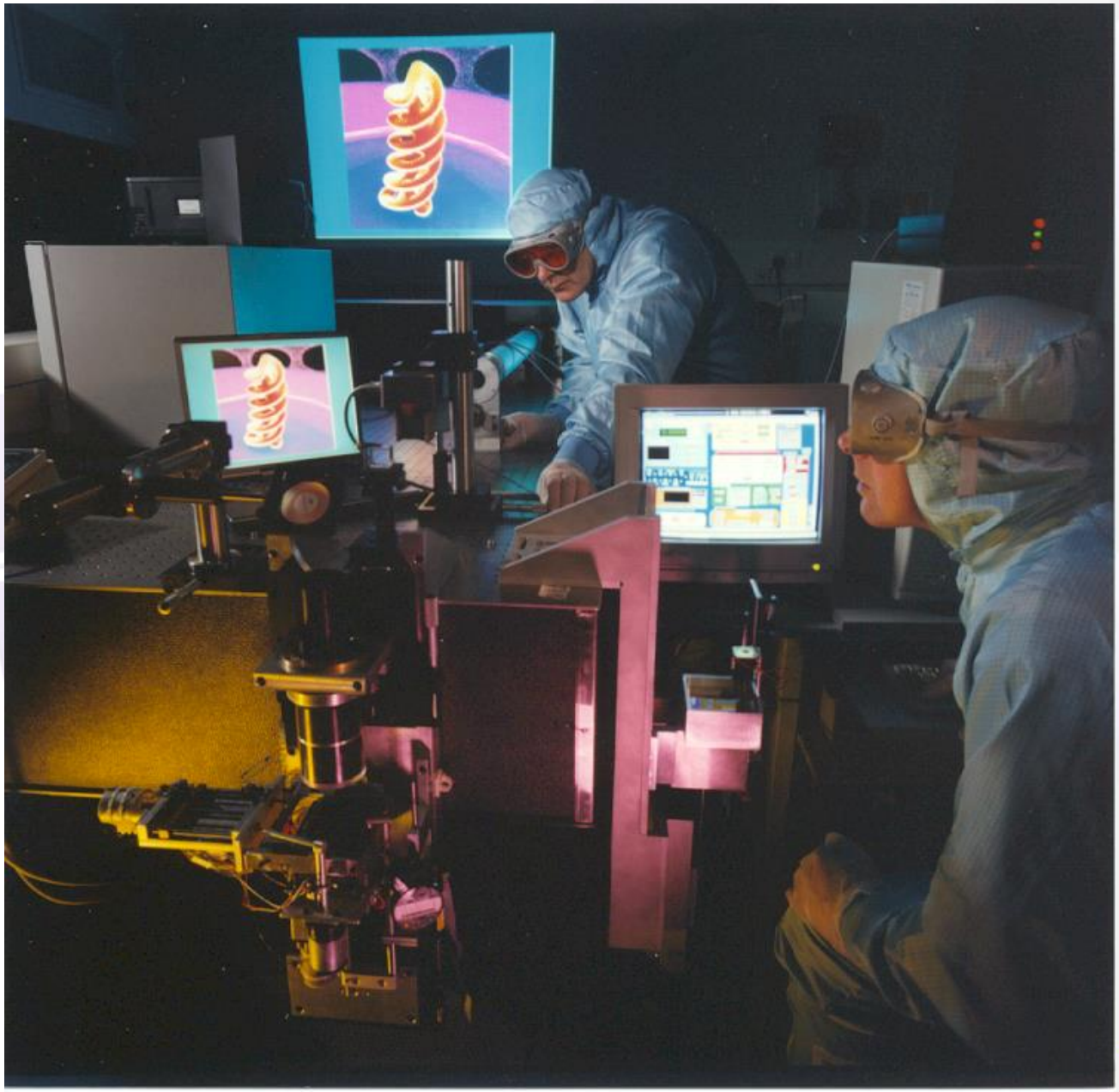

Micro-SLA System

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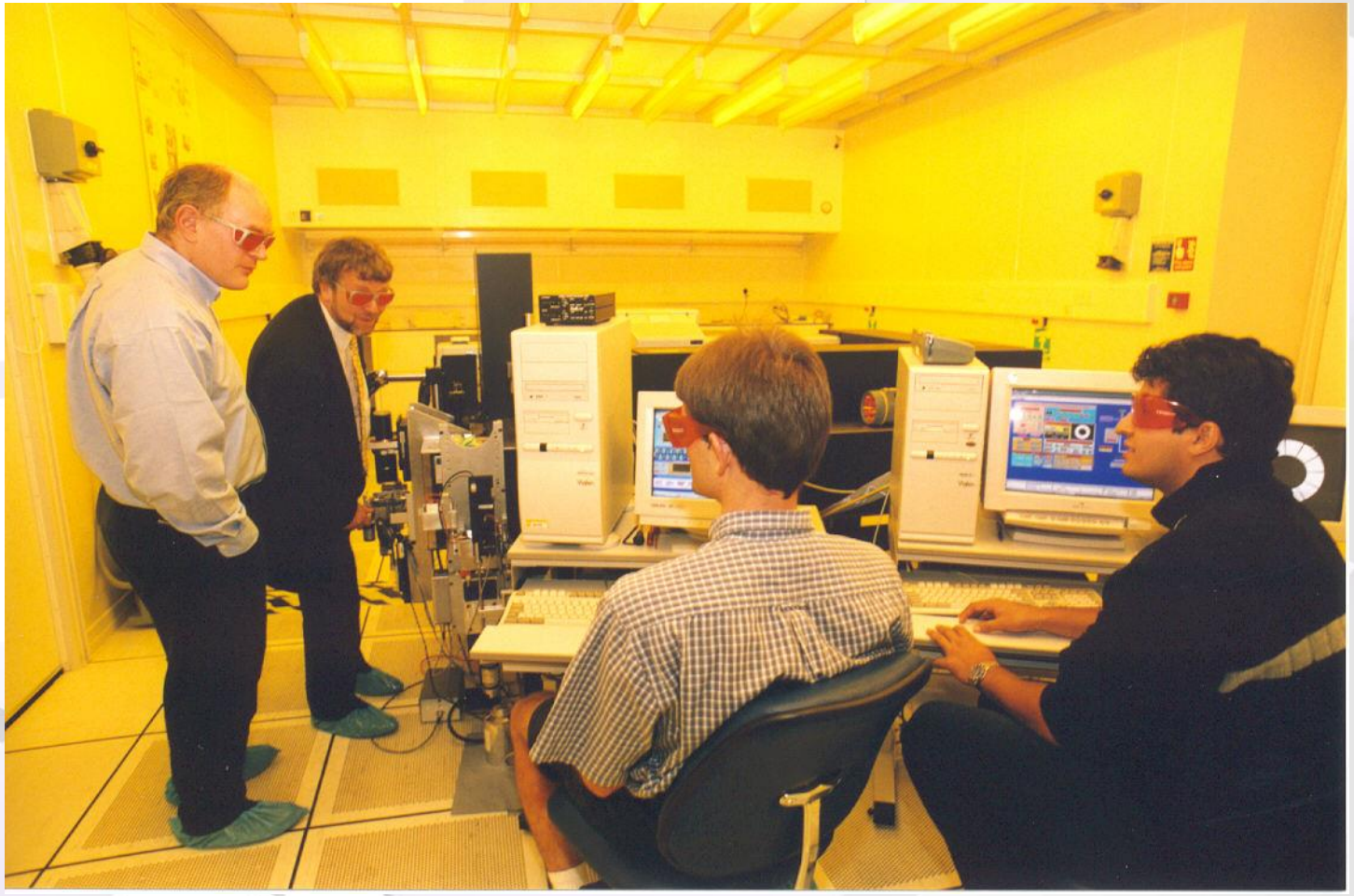
MicroSLA System



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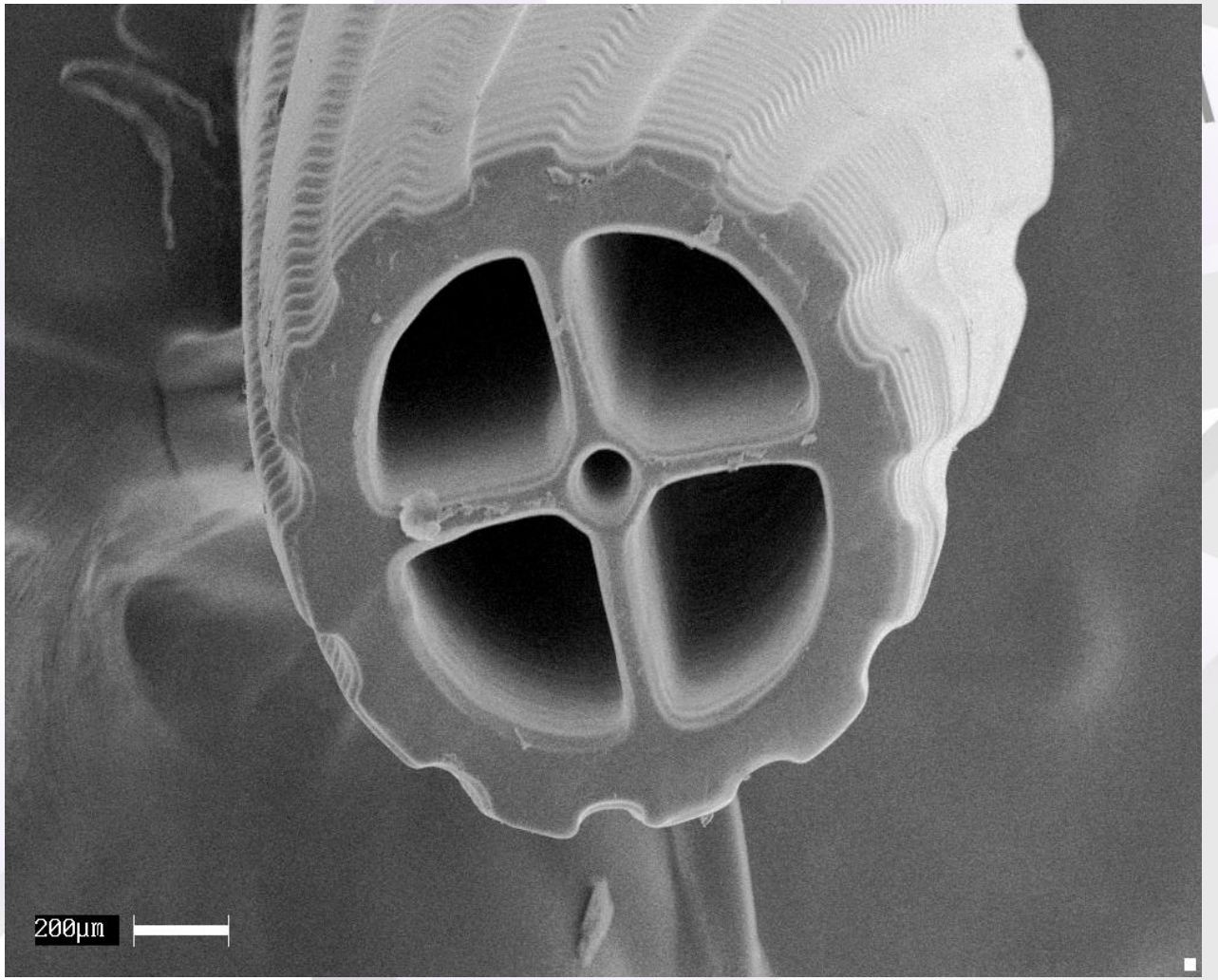
A micro-gear (50 micron layers)



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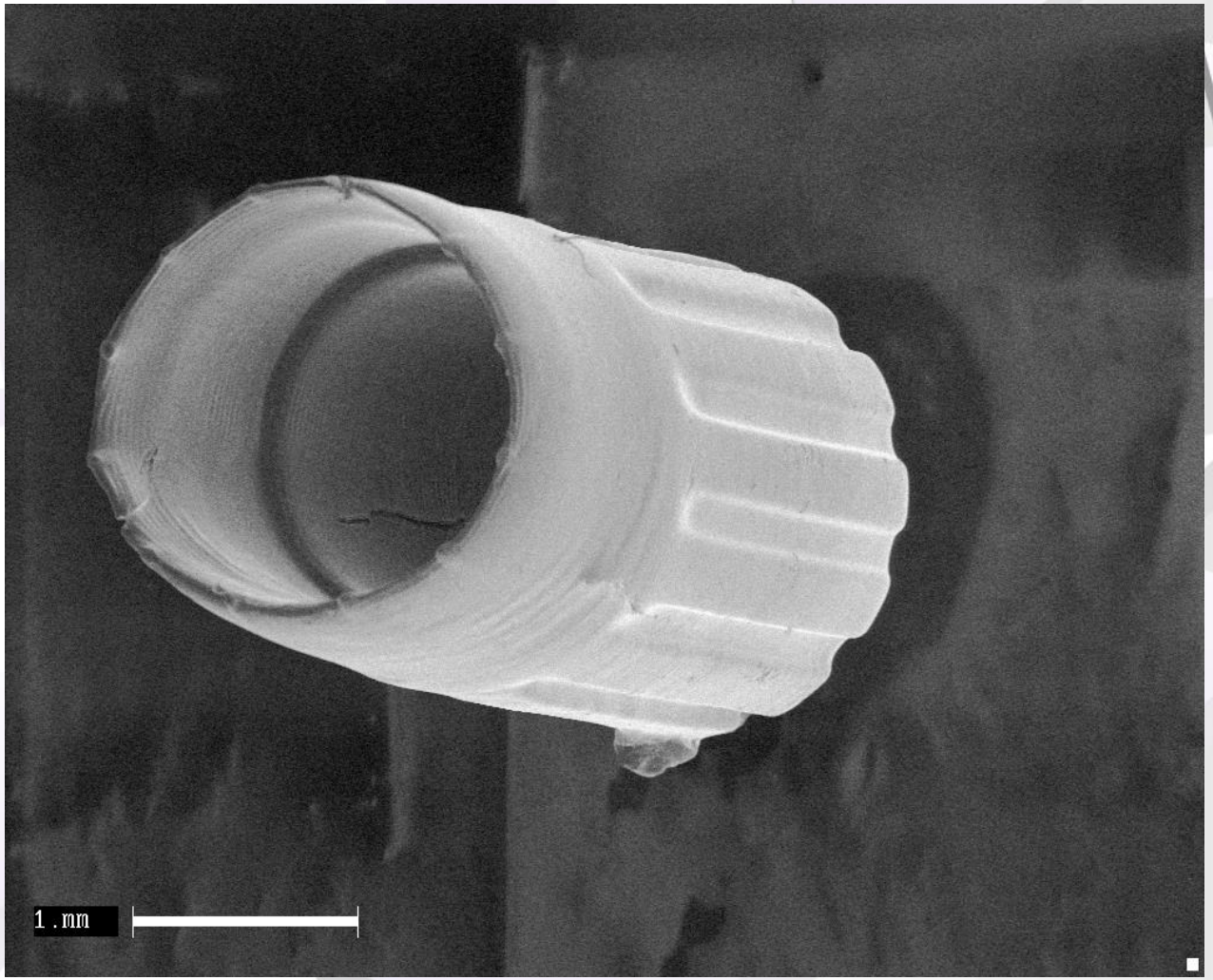
A case for a micro-motor (50 micron layers)



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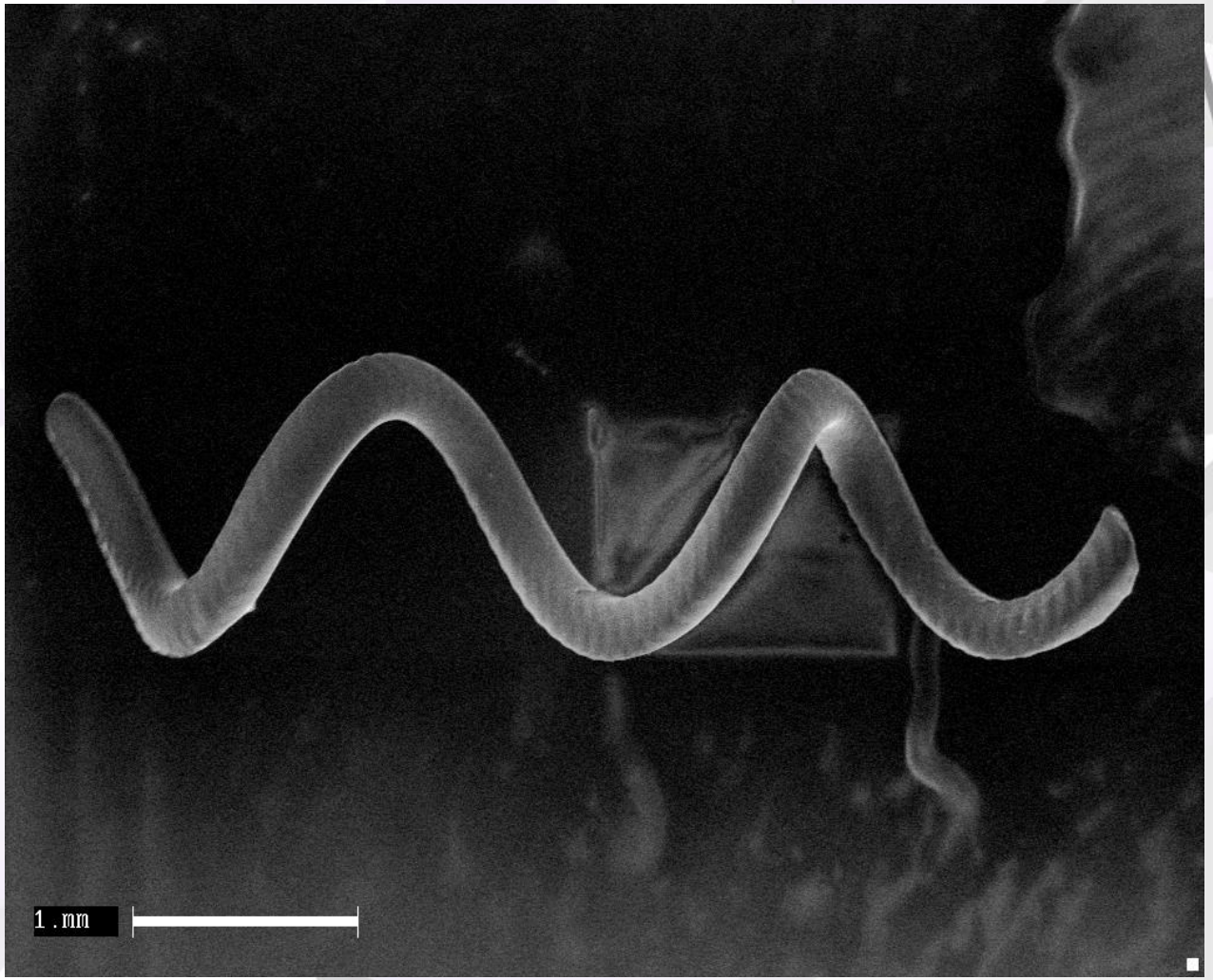
A helix (50 micron layers)



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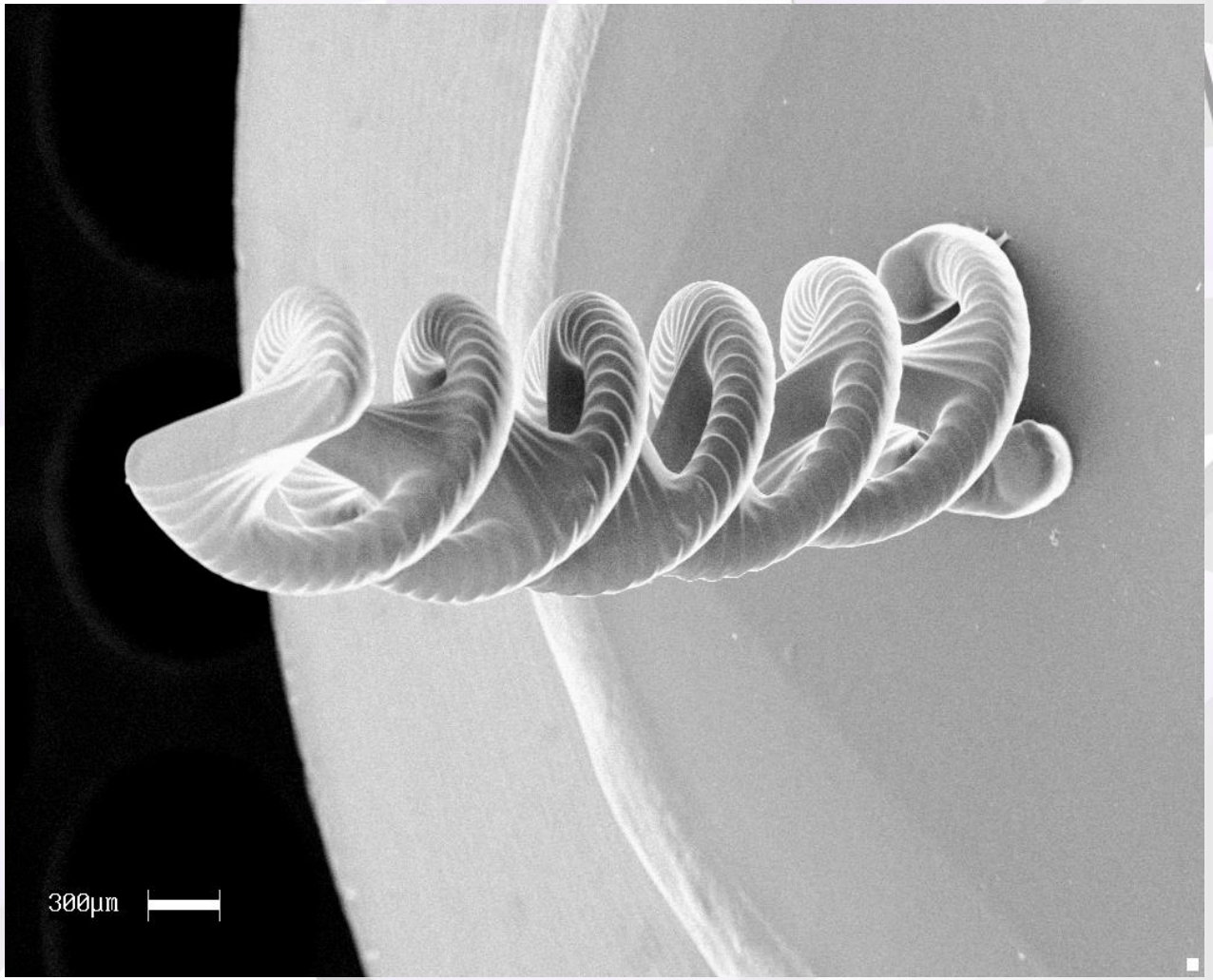
A double helix (50 micron layers)



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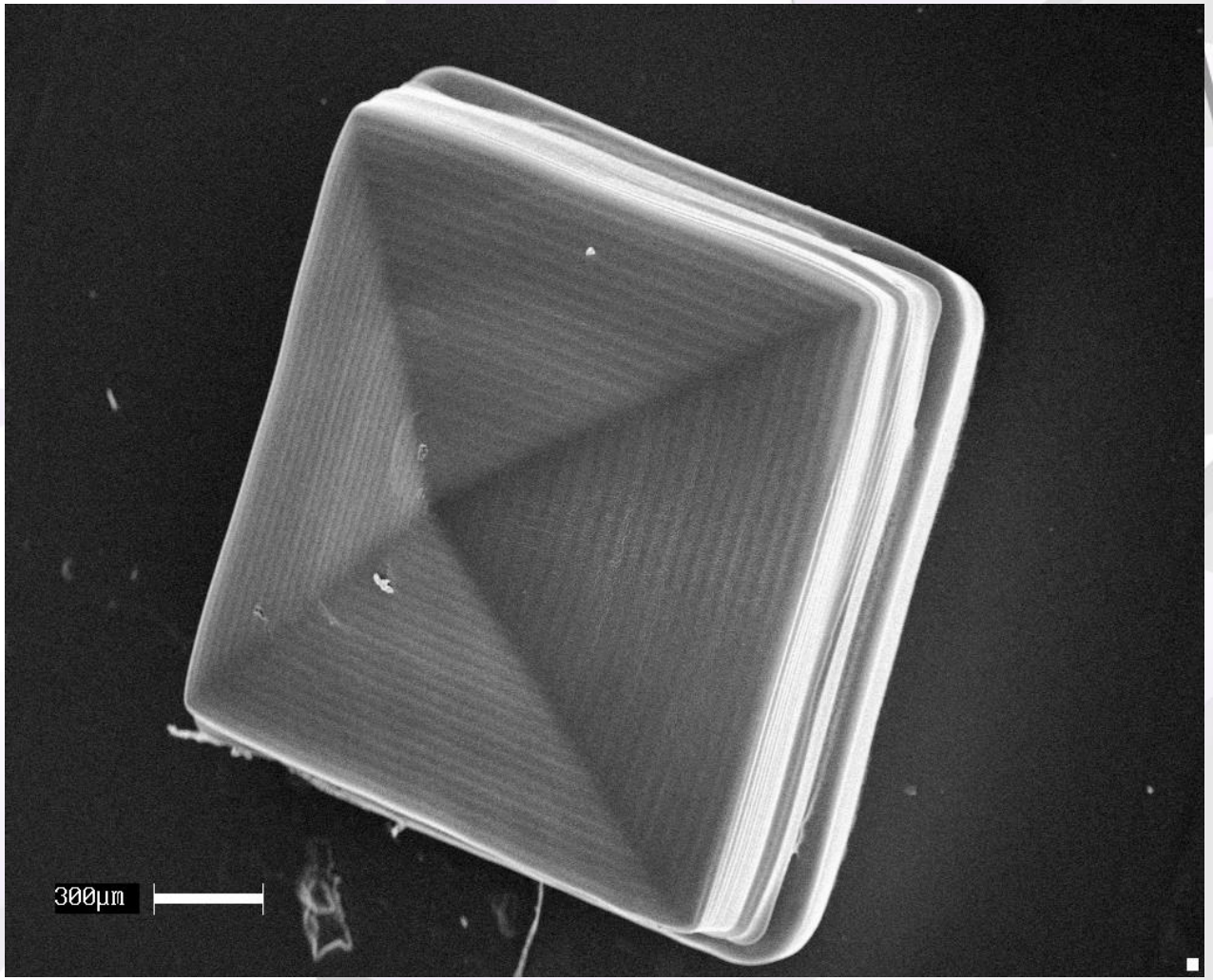
A micro-pyramid (35 micron layers)



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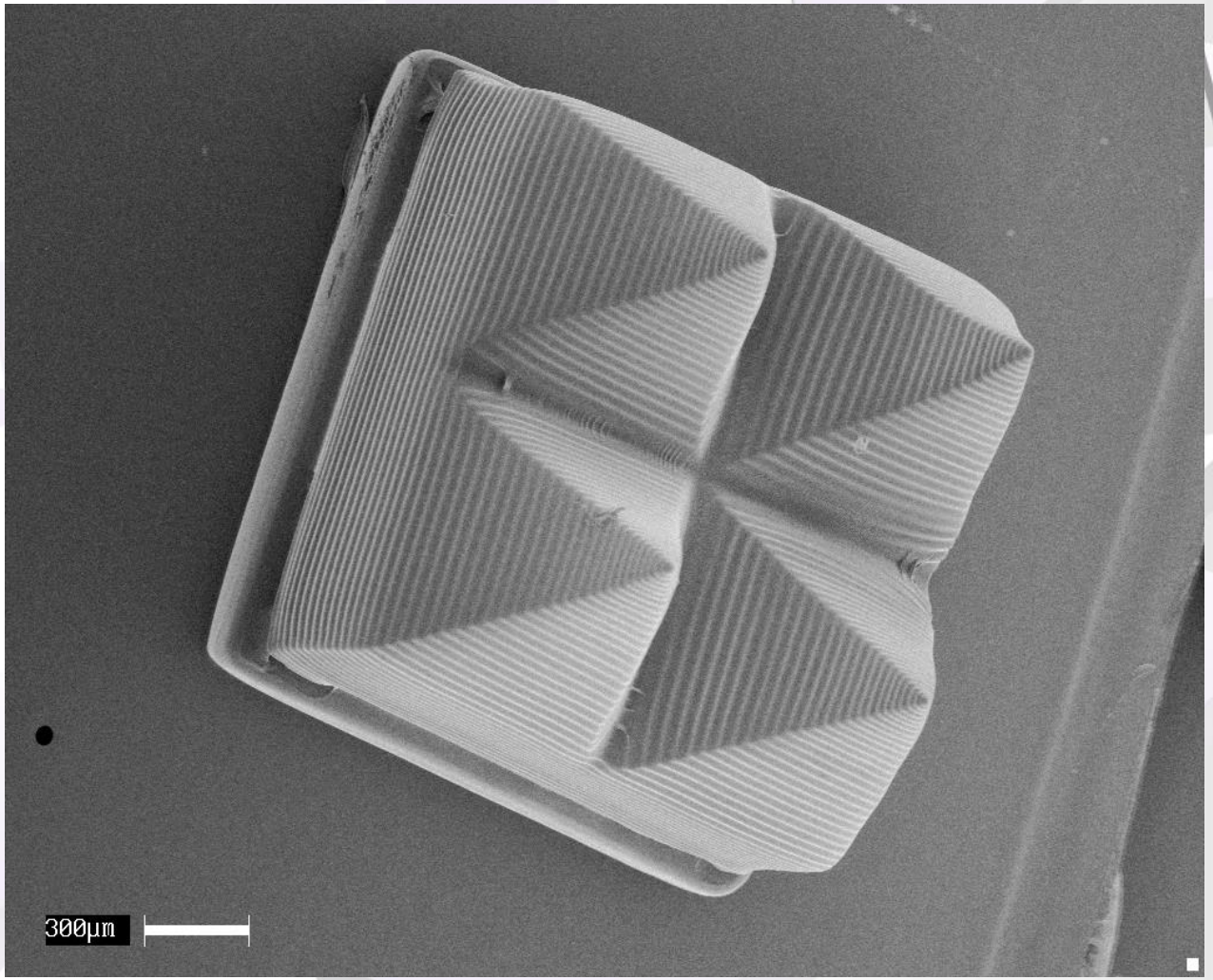
Micro-pyramid (50 micron layers)



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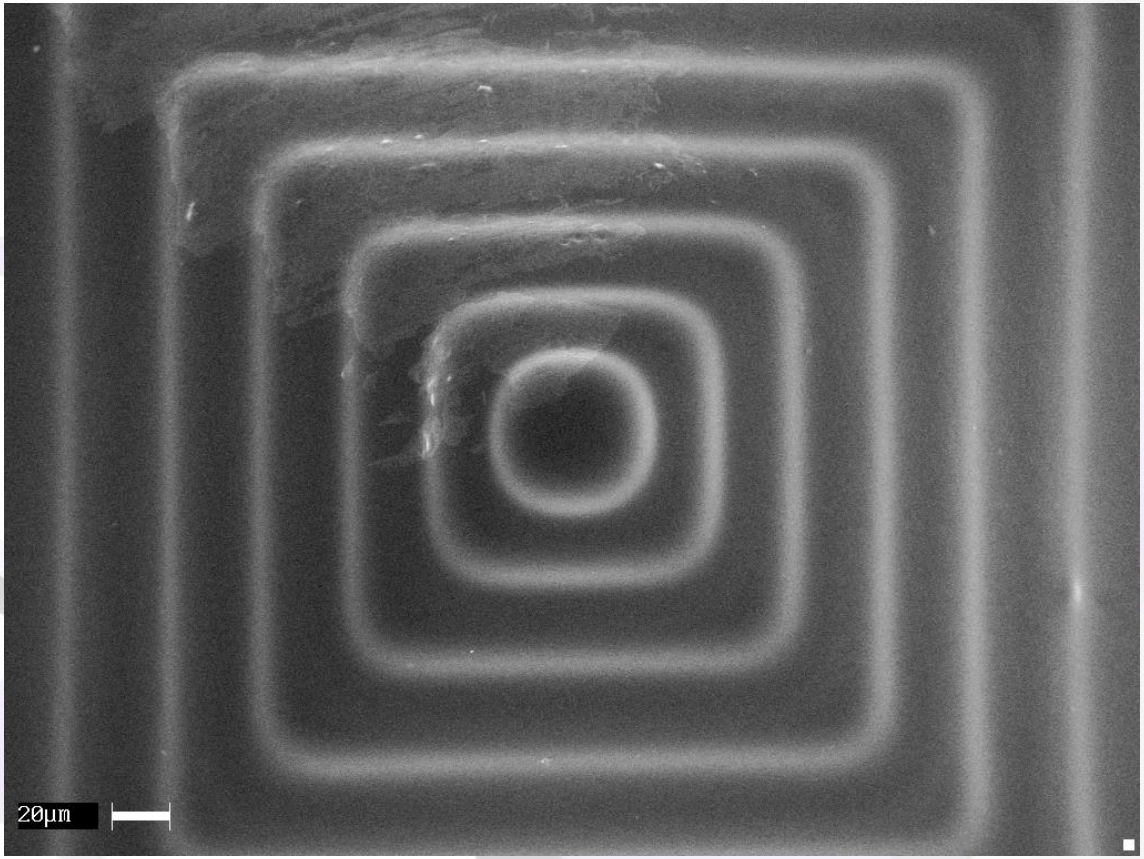
Detail of the centre of a micro -pyramid (25 layers of 50 microns each)



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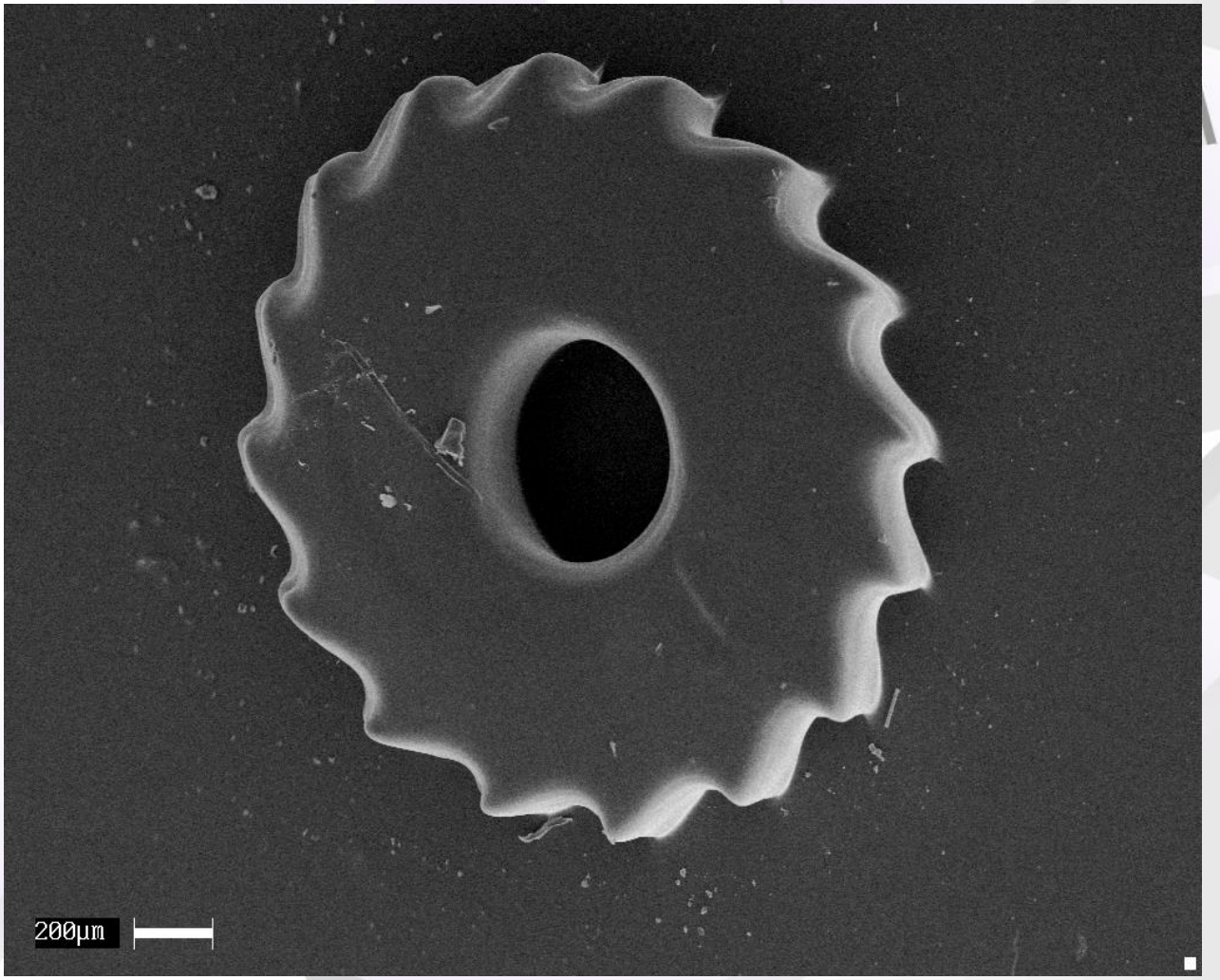
A micro-wheel (5 micron layers)



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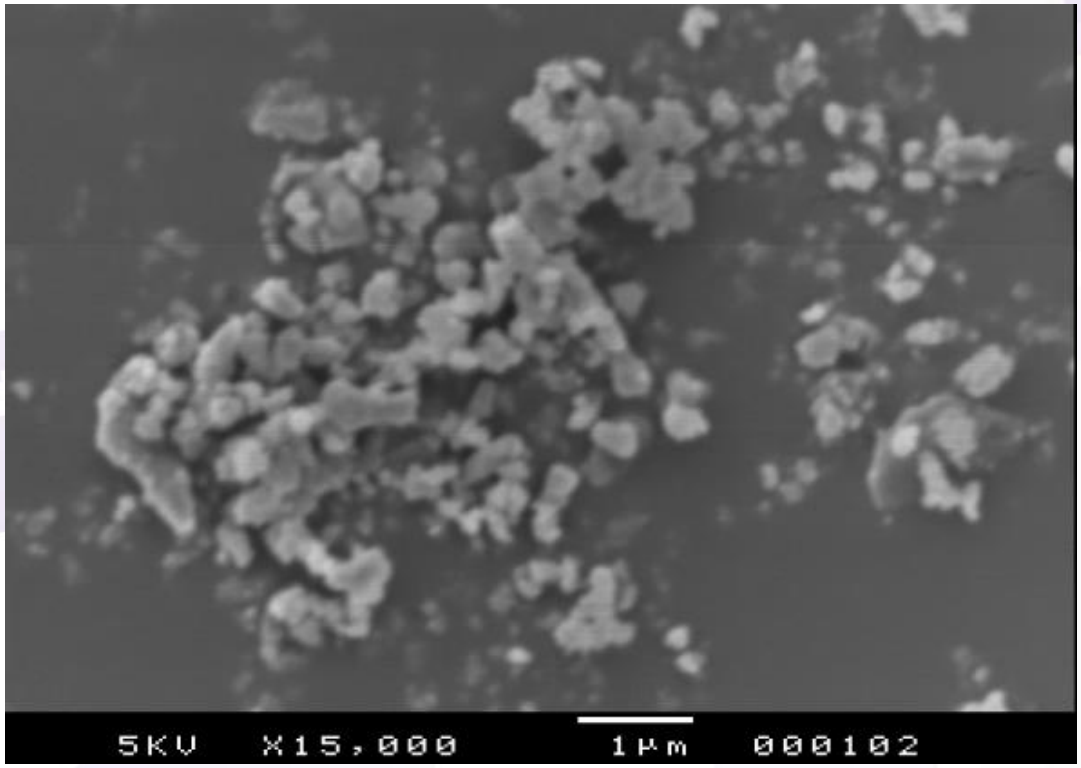
Photopolymer Rapid Opto-electronic Manufacture of Macro/micro Prototype Products – BRITE-EURAM



Alumina (Al_2O_3) Powder: Average diameter 0.5µm; Refractive index 1.7

Monomer: hexane-diol-diacrylate (HDDA)

Photoinitiators:

Igracure 651 (DMPA) absorbs 300-390 nm

Igracure 819 absorbs up to 450 nm

50 mJ/cm^2 for 100 µm cure depths, resolution of 40 µm

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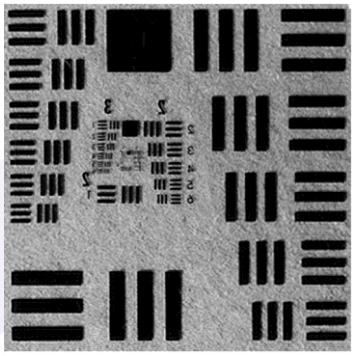
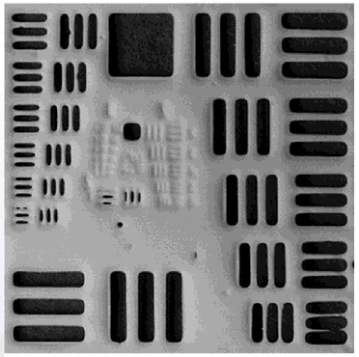
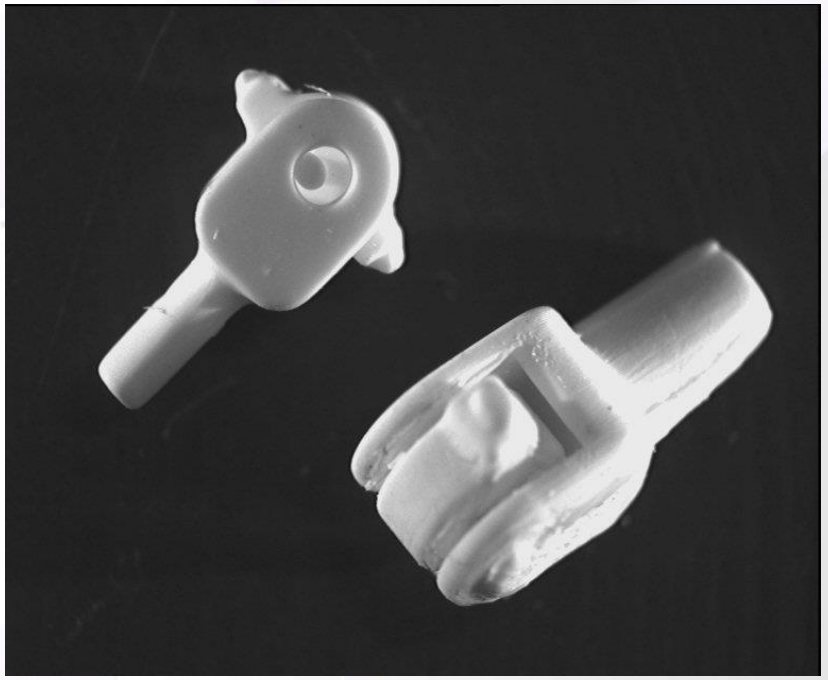
Photopolymer Rapid Opto-electronic Manufacture of Macro/micro Prototype Products – BRITE-EURAM



Mask

Cured at 365 nm with Hg Lamp





Ceramic parts produced with visible source and CRL XGA mask

8mm x 8mm 120 micron thick polymerised layer, resolution 50 microns; 80 wt% alumina, 0.5 wt% DMPA wrt HDDA monomer

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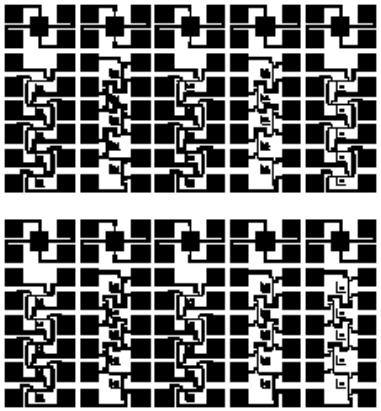
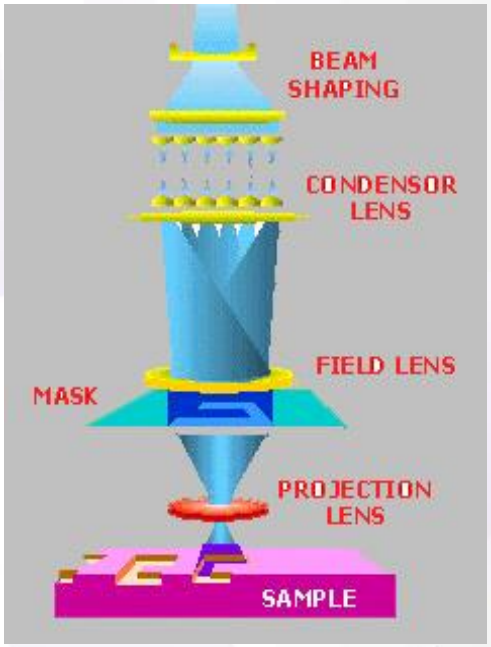
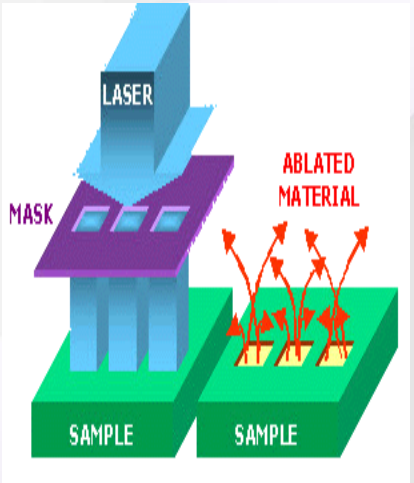
Micromachining - Electronics & Sensors

Lambda Physik LPX 201i, 125W mean power, 2.5J/pulse,100 Hz prf, 10 to 50 ns pulse width



Chrome on Quartz Mask





Micro-fluidic systems

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References

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9) P Birch, R Young, C Chatwin, M Farsari, D Budgett, J Richardson, "Fully complex optical modulation with an analogue ferroelectric liquid crystal spatial light modulator," Optics communications 175 (4), 347-352, 2000
10) PM Birch, R Young, D Budgett, C Chatwin, "Two-pixel computer-generated hologram with a zero-twist nematic liquid-crystal spatial light modulator," Optics letters 25 (14), 1013-1015, 2000
11) P Birch, R Young, M Farsari, C Chatwin, D Budgett, "A comparison of the iterative Fourier transform method and evolutionary algorithms for the design of diffractive optical elements," Optics and Lasers in engineering 33 (6), 439-448, 2000
12) P Birch, R Young, D Budgett, C Chatwin, "Dynamic complex wave-front modulation with an analog spatial light modulator," Optics letters 26 (12), 920-922, 2001

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